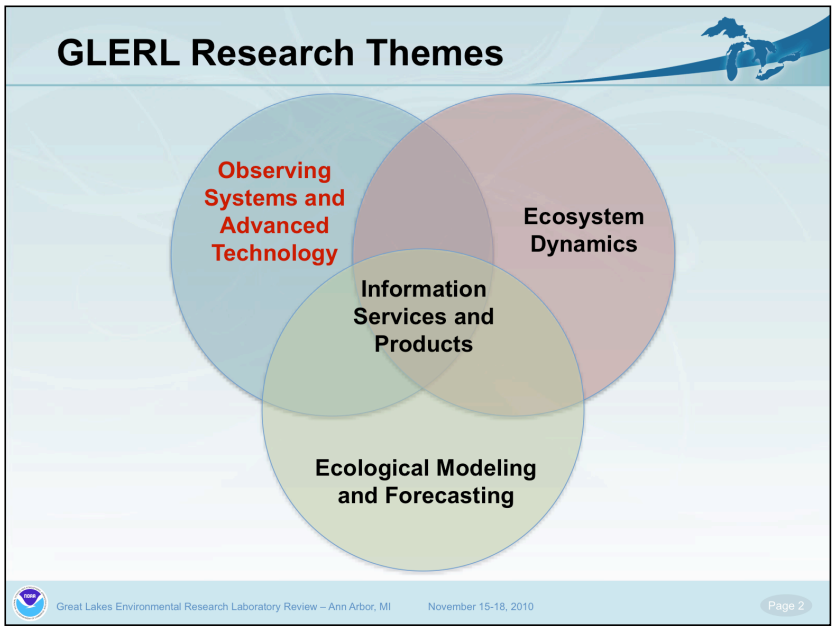
Team Members:

George Leshkevich, Dennis Donahue, Ronald Muzzi, Songzhi Liu, John Lane, Steve Constant, Greg Lang, Mike Taetsch, Andrew Yagiela, Tom Joyce, Steve Bawks, Jack Workman



GLERL historically addressed observing and technology research needs on a project basis and is now transitioning to a more proactive and integrated approach.

Observing Systems and Advanced Technology Theme provides a forward looking approach to enhance observing capabilities:

- Working towards an integrated observation system
- In pursuit of the most advanced scientific tools
- Enabling Model/Forecast Validation
- Contributing to Satellite, Sensor, and Model Calibration

NOAA Goals

NOAA 5-Year Research Plan

- Emphasizes the integration of the *observational, experimental*, and *analytical tools* that are at the core of NOAA's research

NOAA Mission Support Goal

- Satellite
- Fleet
- Modeling and Observations Infrastructure

What improvements to observing systems and analysis approaches will lead us to better predictions?

This question is one of the overarching research questions in the NOAA 5 Yr Research Plan.

NOAA 5 Yr Strategic Plan Technology and Mission Support Goal: Provide Critical Support for NOAA's Mission

Observation Systems and Advanced Technology: Overview

- Theme Overview
  - Laboratories
  - Observation Platforms
  - Sensor Development
  - Real-time Observations
  - Great Lakes Observing System Regional Association
- Satellite Remote Sensing
- Great Lakes Vessel Operations
- Data Acquisition and Data Management

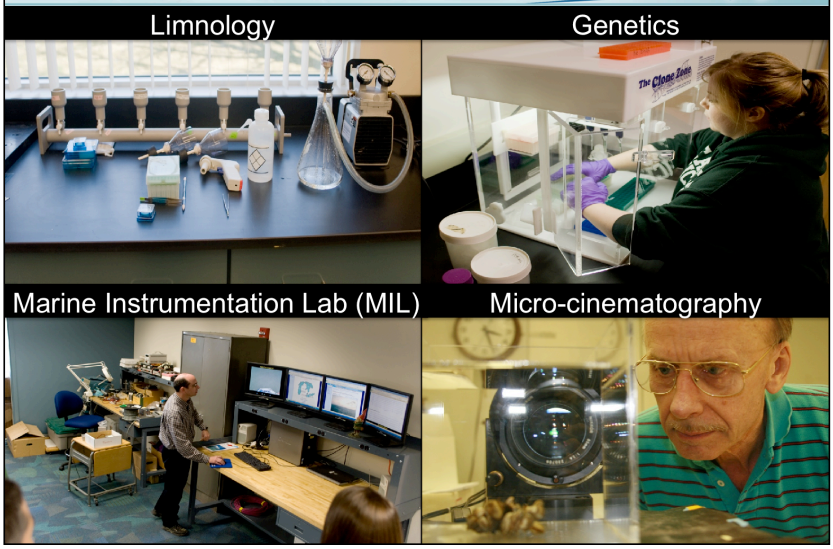
Theme Overview: Steve Ruberg
Satellite Remote Sensing: George Leshkevich
Great Lakes Vessel Operations: Dennis Donahue
Data Acquisition & Data Management: Ron Muzzi

Observing Systems and Advanced Technology Objectives

At GLERL, we will strengthen and integrate our observing system infrastructure by connecting engineering and science:

- In pursuit of the most advanced scientific tools
- Enabling Model/Forecast Validation and Verification
- Enabling Satellite and *In Situ* Sensor Calibration
- Working towards an integrated observation system

Overview of Ann Arbor Laboratories



GLERL Laboratories:

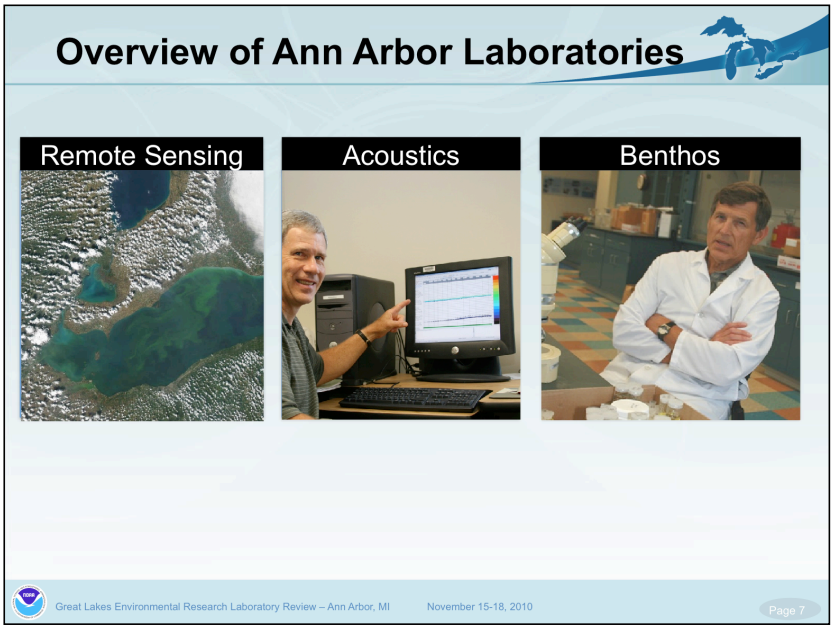
Limnology Lab: standard wet chemistry techniques for water sample analysis, nutrient analysis, CHN, Dissolved Organic Carbon, Total Suspended Solids, and chlorophyll

Genetics Lab: PCR, Quantitative PCR, and DNA Sequencing to identify toxic HABs

Working with MBARI on moving lab-based PCR techniques into the field

Marine Instrumentation Lab: Focused on design and build of data acquisition/instrumentation packages and platforms with capabilities for electronics design, computer software, instrument calibration, and mooring design and deployment

Micro-Cinematography Lab: video microscope mounted on a three- dimensional motor drive applied to zooplankton and benthic observations

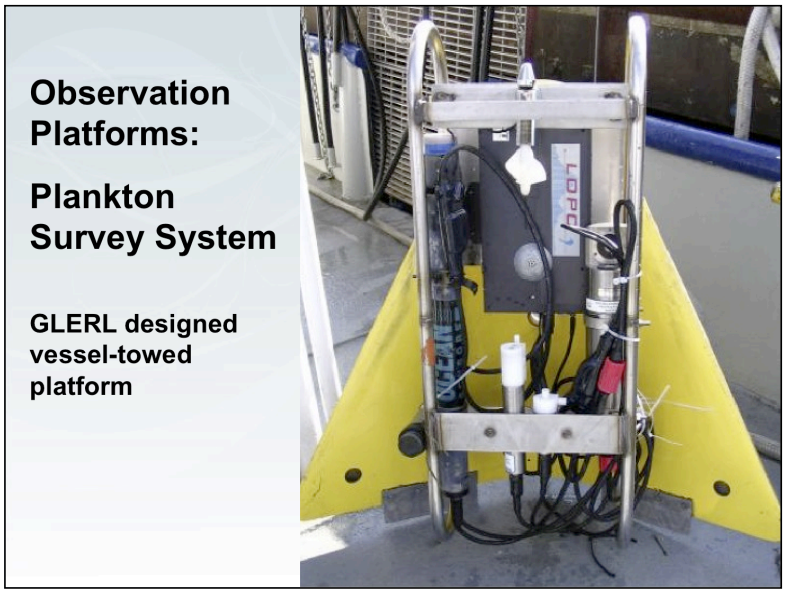


Remote Sensing Lab: near real-time Great Lakes satellite observations supporting research and decision making

Acoustics Lab: field prep and data post-processing of fisheries benthic and pelagic acoustic observations

Benthos Lab: processing biological samples including invasive mussels and native amphipods

Muskegon & Shipboard Laboratory capabilities:
Ecology Lab: fish/diet ecology and invertebrate ecology; microscopes and bomb calorimetery instrumentation
Phytoplankton Lab: primary productivity lab and microscope room; GLERL's only radio-isotope approved lab.



The PSS is the first of two examples of observation platforms used for research at GLERL. The PSS is a towed vehicle designed for ecosystem observations using a Laser Optical Plankton Counter (LOPC) integrated with additional sensors measuring photosynthetic active radiation (PAR), chlorophyll, turbidity, conductivity, oxygen and temperature. All parameters are registered with depth and latitude/longitude. The vehicle is towed behind the GLERL vessel Laurentian along with a fisheries acoustic system providing observations of food-web dynamics.

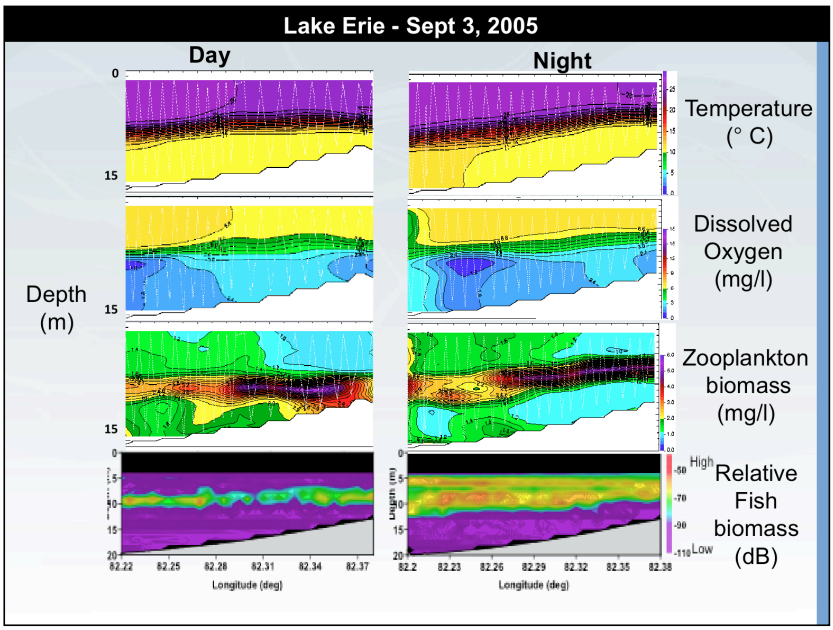
Research Products:

VANDERPLOEG, H.A., S.A. LUDSIN, S.A. RUBERG, T.O. Hook, S.A. POTHOVEN, S.B. Brandt, G.A. LANG, J.R. LIEBIG, and J.F. CAVALETTO. Hypoxia affects spatial distributions and overlap of pelagic fish, zooplankton, and phytoplankton in Lake Erie. *Journal of Experimental Marine Biology and Ecology* 381:S92-S107 (2009).

VANDERPLOEG, H.A., T.H. JOHENGEN, P.J. Lavrentyev, C. Chen, G.A. LANG, M.A. Agy, M.H. Bundy, J.F. CAVALETTO, B.J. EADIE, J.R. LIEBIG, G.S. MILLER, S.A. RUBERG, and M.J. McCORMICK. Anatomy of the recurrent coastal sediment plume in Lake Michigan and its impacts on light climate, nutrients, and plankton. *Journal of Geophysical Research* 112(C03S90, doi: 10.1029/2004JC002379):23 pp. (2007).

LIEBIG, J. R., H. A. VANDERPLOEG, and S. A. RUBERG. Factors affecting the performance of the optical plankton counter in large lakes: insights from Lake Michigan and laboratory studies. *Journal of Geophysical Research* 111(C05S02):10 pp. (2006).

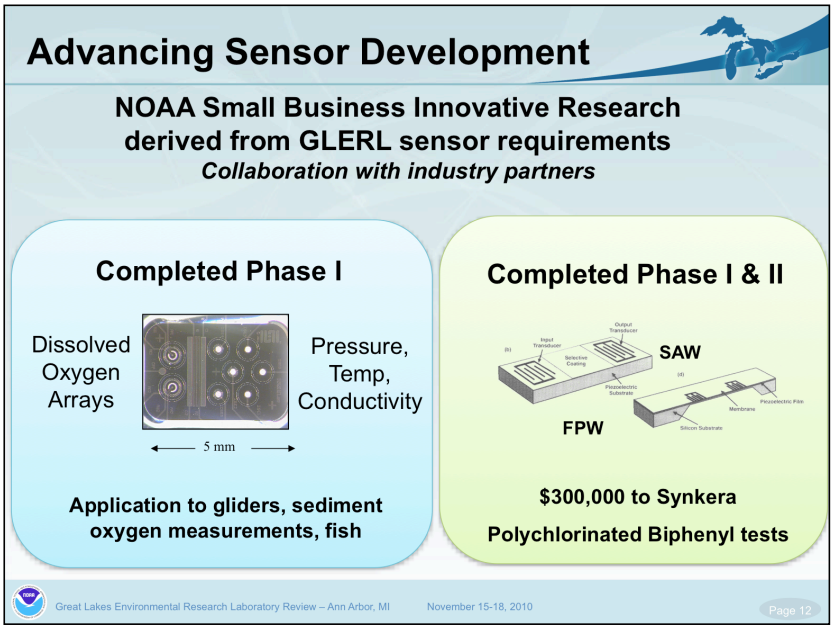
RUBERG, S. A., H. A. VANDERPLOEG, J. F. CAVALETTO, G. A. LANG, J. R. LIEBIG, T. C. MILLER, and M. AGY. Plankton survey system. Proceedings of the Oceans 2001 MTS/IEEE Conference, Honolulu, HI, November 5-8, 2001. Marine Technology Society, Washington, DC, pp. 1899-1903 (2001).



This slide represents a day and night snapshot of a transect in Lake Erie's central basin captured by the PSS during the International Field Years on Lake Erie (IFYLE) project. The data collected in 2005 is representative of typical September conditions in Lake Erie's central basin in with a strong hypolimnion and very low oxygen levels. The vertical axis on the left indicates water depth and the scale on the right shows a color scale representing temperature on the top followed by dissolved oxygen, zooplankton biomass, and fish biomass on the bottom plots. In the temperature plot on the top, cooler temperatures are shown in yellow (~ 11 °C) and warmer temperatures are shown in purple (~ 27 °C). A slight variation between day and night in the temperature transect can likely be attributed to internal waves that are common during Oxygen levels above the thermocline are 6-7 mg/l while in the hypolimnion levels are in the 1-2 mg/l range. The greater portion of the zooplankton biomass is located just beneath the thermocline in the daytime plot and likely feeding at night at the thermocline. Lastly,in the daytime the fish reside just above the thermocline where oxygen levels are adequate and disperse at night during feeding. One possible explanation of the zooplankton's daytime behavior, their movement into hypoxic waters, is to avoid fish predation. The data collected by the PSS provides GLERL scientists and engineering staff Lake Erie of ecosystem dynamics and can be used to communicate Lake Erie behavior to constituents.

GLERL has also worked with collaborators to develop a benthic mapping capability using remotely operated vehicles.
Partnerships with Grand Valley State U., U. Wisconsin, U. Michigan, Wayne State U. and Thunder Bay National Marine Sanctuary have been leveraged to provide a multi-disciplinary understanding of submerged sinkholes in Lake Huron. The project has served to improve our understanding of an unusual groundwater-fed ecosystem resulting in research publications and has served an interpretive role for TBNMS providing information to divers for this destination.
Technology Development: Sensor integration, Positioning system integration, Mapping of parameters measured

Biddanda, B., S.C. Nold, S.A. RUBERG, S.T. Kendall, T.G. Sanders, and J.J. Gray. Great Lakes sinkholes: A microbiogeochemical frontier. *EOS Transactions* 90(8):61-68 (2009).
RUBERG, S.A., S.T. Kendall, B.A. Biddanda, T. Black, S.C. Nold, W.R. Lusardi, R. Green, T. Casserley, E. Smith, T.G. Sanders, G.A. LANG, and S.A. CONSTANT. Observations of the Middle Island sinkhole in Lake Huron: A unique hydrogeologic and glacial creation of 400 million years. *Marine Technology Society Journal* 42(4):12-21 (2009).
Biddanda, B. A., D. F. Coleman, T. H. JOHENGEN, S. A. RUBERG, G. A. Meadows, H. W. VanSumeren, R. R. Rediske, and S. T. Kendall. Exploration of a submerged sinkhole ecosystem in Lake Michigan. *Ecosystems* 9:828-842 (2006).
RUBERG, S.A., D.F. Coleman, T.H. JOHENGEN, G.A. Meadows, H.W. VanSumeren, G.A. LANG, and B.A. Biddanda. Groundwater plume mapping in a submerged sinkhole in Lake Huron. *Marine Technology Society Journal* 39(2):65-69 (2005).

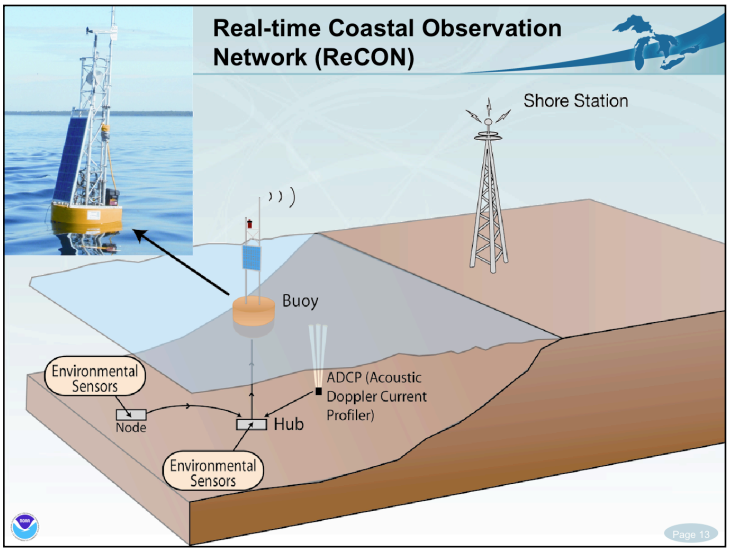


Sensor Development

The Small Business Innovative Research projects have led to sensor collaborations involving industry and universities with NOAA in the role of feasibility demonstrations - so far applied to HABs.
SBIR is congressionally mandated NOAA-wide program that obtains research topics from NOAA scientists and then solicits proposals from small business for these topics. Examples of SBIR topic parameters of interest:

	Range	Resolution
Phosphate	0.5-3.0 ug P/L	0.1 ug P/L
Microcystin (HAB)	0.1 – 5 ug/L	0.1 ug/L

This project has led to collaborations with industry on proposals such as the National Oceanographic Partnership Program, proposal development with academic researchers, the MEMS “foundry” in Toledo OH, and the recent NOAA PCMHABs program proposal with NASA and FIU on “lab on a chip” technology to detect HABs toxin.



Real-Time Observations

"*Successful ecosystem forecasting and forecast validation depend on the availability of data describing the present state of coastal waters at a variety of time and space scales*"

(GLERL Science Strategy)

. Derivation of Martha's Vineyard Coastal Observatory, T. Austin WHOI
. Wireless Internet System
. High Bandwidth Applications
. Ethernet Compatible
. Seabed to Sea Surface Operation
. Standard Multiple Sensor Inputs
. Leverages advantages of our present wired and wireless world

Network-based real-time observing system architecture positions GLERL to collaborate on MBARI and NSF OOI advanced hardware and software projects. NEPTUNE Canada and NSF indicate that observing systems provide an opportunity for "transformational science".

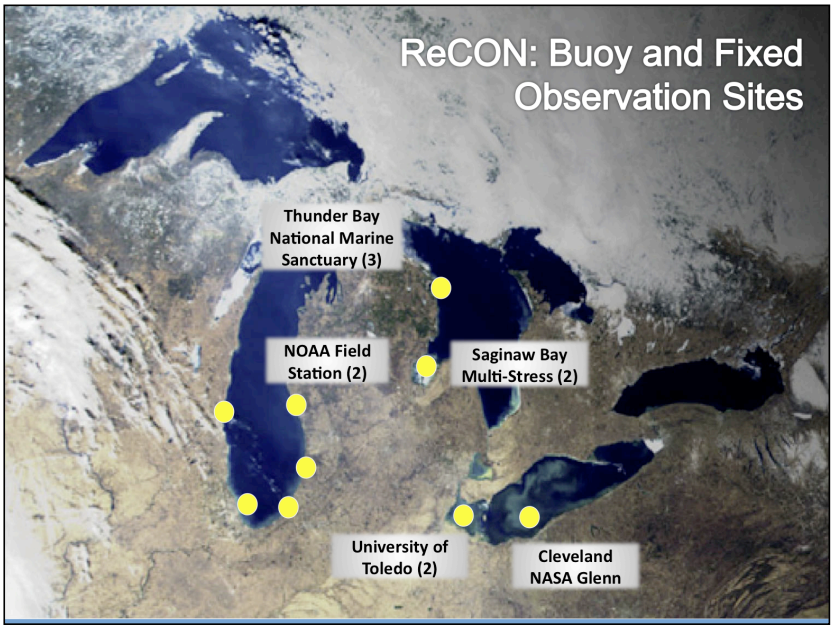
RUBERG, S.A., E. Guasp, N. HAWLEY, R.W. MUZZI, S.B. BRANDT, H.A. VANDERPLOEG, J.C. LANE, T.C. MILLER, and S.A. CONSTANT. Societal benefits of the real-time coastal observation network (ReCON): Implications for municipal drinking water quality. *Marine Technology Society Journal* 42(3):103-109 (2008).

RUBERG, S.A., R.W. MUZZI, S.B. BRANDT, J.C. LANE, T.C. MILLER, J.J. Gray, S.A. CONSTANT, and E.J. Downing. A wireless internet-based observatory: The Real-time Coastal Observation Network (ReCON). Proceedings, Marine Technology Society/IEEE Oceans 2007 Conference, Vancouver, British Columbia, Canada, September 30-October 5, 2007. 6 pp. (2007).

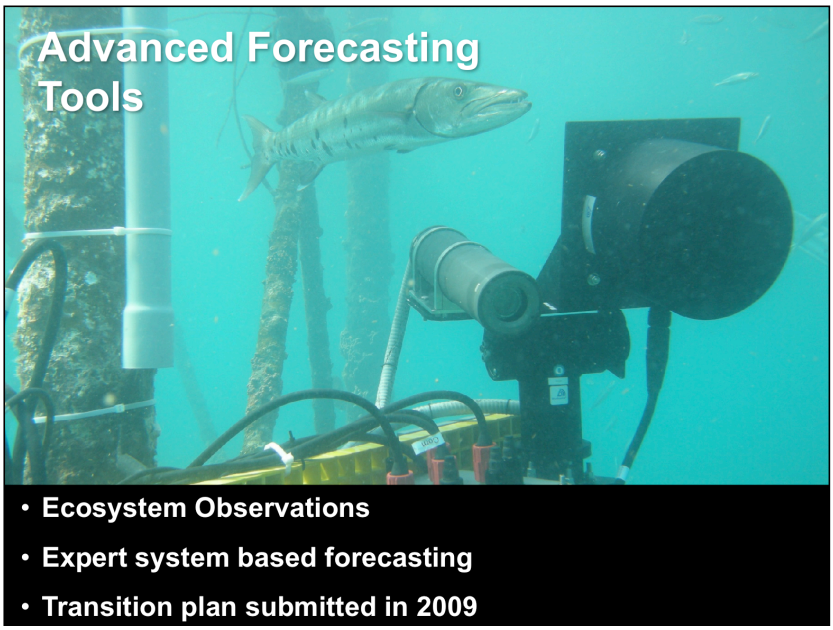
RUBERG, S.A., S.B. BRANDT, R.W. MUZZI, N. HAWLEY, T. Bridgeman, G.A. LESHKEVICH, J.C. LANE, and T.C. MILLER. A wireless real-time coastal observation network. *EOS Transactions* 88(28): 285-286 (2007).

ReCON System Drivers

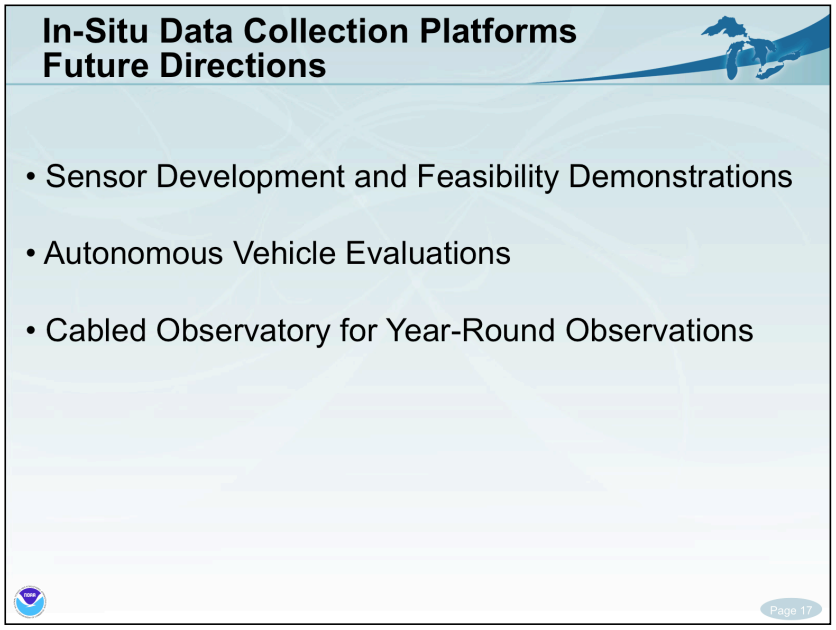
- Model/forecast input for GLERL and collaborator researchers
- Observations affecting water quality to regional managers
- Storm and rip current verification to NWS marine forecasters
- Telepresence outreach tools for NMS and GLERL partners



Initial meteorological observing technology, deployed on piers at the five Lake Michigan locations supporting GLERL physical modeling work, was transitioned to regional NWS marine forecasters. Real-time observations are being pushed into the National Observing System (data management presentation following). More advanced ReCON stations have now been deployed addressing rip current warnings, fisheries restoration, Thunder Bay National Marine Sanctuary telepresence, harmful algal bloom research and warnings, and water quality observations provided to water intake managers.



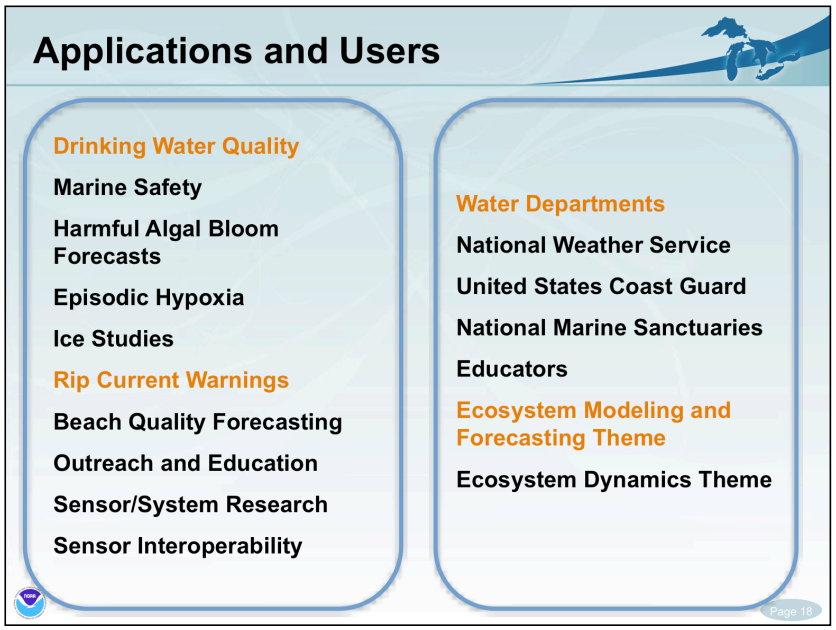
Demonstration Project: NOAA Atlantic Oceanographic and Meteorological Laboratory, GLERL, Florida Keys National Marine Sanctuary, Florida Institute of Oceanography feasibility study. This project demonstrates the value of real-time data for monitoring and assessment of fishes, insight into temporal behavior and variation, and for event response by fisheries managers.



Collaboration with Rutgers under the former National Undersea Research Program at U. Conn. using REMUS vehicle.

Collaboration with industry partner SeaLandAire on the Autonomous Surface Platform.

Currently working with Industry and the Cooperative Institute on autonomous underwater vehicles and gliders.



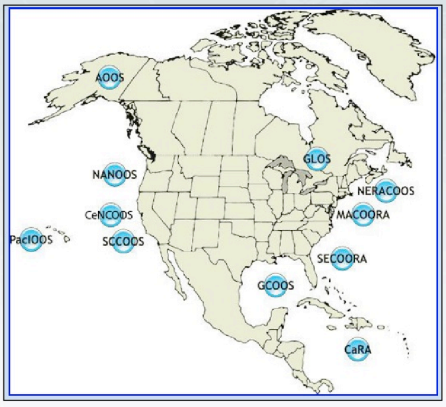
Many projects are coordinated with other Theme areas. E = Ecosystem Dynamics Theme, M = Modeling and Forecasting Theme

- **Central Lake Erie –** Drinking Water Quality Observations (Cleveland Water Dept., M), Marine Safety (NWS, USCG)
- **Western Lake Erie –** HABs (M,E), Episodic Hypoxia / Fishery (E), Marine Safety, Ice Studies, Monroe Public Schools
- **Lake Michigan –** Rip Current Warnings (NWS), Beach Forecasting, Marine Safety, Ecosystem/Fisheries Research (E)
- **Lake Huron, Thunder Bay National Marine Sanctuary –** Marine Safety, Outreach and Education, Fisheries Research (E)
- **Observing Systems Engineering Research –** Sensor/system research, sensor interoperability, HD Video for NMS

ReCON Products

- Model/forecast input observations to GLERL and collaborating researchers
- Observations affecting water quality to regional managers
- Storm and rip current verification to National Weather Service marine forecasters
- Telepresence outreach tools for National Marine Sanctuaries and GLERL partners

Great Lakes Observing System Regional Association



- GLERL is leading the design of the operational component of Great Lakes observing system
- Industry led enterprise approach to deploy the *operational* component of GLOS
- A nine month contract awarded to LimnoTech on Sept. 21st, 2010

GLOS is one of 11 regional nodes of the U.S. Integrated Ocean Observing System (IOOS). GLERL's modeling and observation expertise has contributed to GLOS startup.
Intentionally owns no observing system assets, but relies on regional universities and GLERL for on-water data observations.
GLOS RA is focused on providing modeling, open water observations, and remote sensing products to meet Great Lakes needs for physical and ecological forecasting, drinking water quality, beach water quality, and Great Lakes Restoration Initiative goals.
Near Term Design Study
GLERL is the lead for the design of a Great Lakes coastal observing system.
Industry-led project to deploy the operational component of GLOS
Contract awarded to LimnoTech on Sept. 21st.
Participants: LimnoTech, ASA, Clarkson U, MTRI, UM Duluth, NOAA GLERL, Environmental Protection Agency, Great Lakes Observing System Regional Association, and Integrated Ocean Observing System.
GLOS RA is supporting user input and modeling and forecasting and observation system research. The Design Study addresses the inclusion of industry in the operational component.

Observation Systems and Advanced Technology

- **Theme Overview**
  - GLERL Labs
  - Observation Platforms
  - Sensor Development
  - GLERL Real-time Observations
  - GLOS RA and Near-Term Design Study
- **Satellite Remote Sensing**
- **Vessel Operations**
- **Data Acquisition and Data Management**

Questions

Observing Systems and Advanced Technology Wrap up

THE WHITE HOUSE COUNCIL ON ENVIRONMENTAL QUALITY

Final Recommendations Of The Interagency Ocean Policy Task Force July 19, 2010

Ocean Policy Task Force Priority Objective Team #9

Recommendation for ***Ocean, Coastal, and Great Lakes Observations, Mapping, and Infrastructure***:

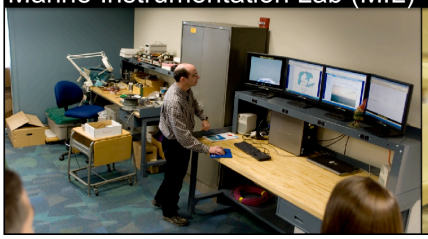
Strengthen and integrate Federal and non-Federal ocean **observing systems, sensors, data collection platforms, data management, and mapping capabilities** into a national system **and integrate that system**

GLERL Laboratories

Limnology

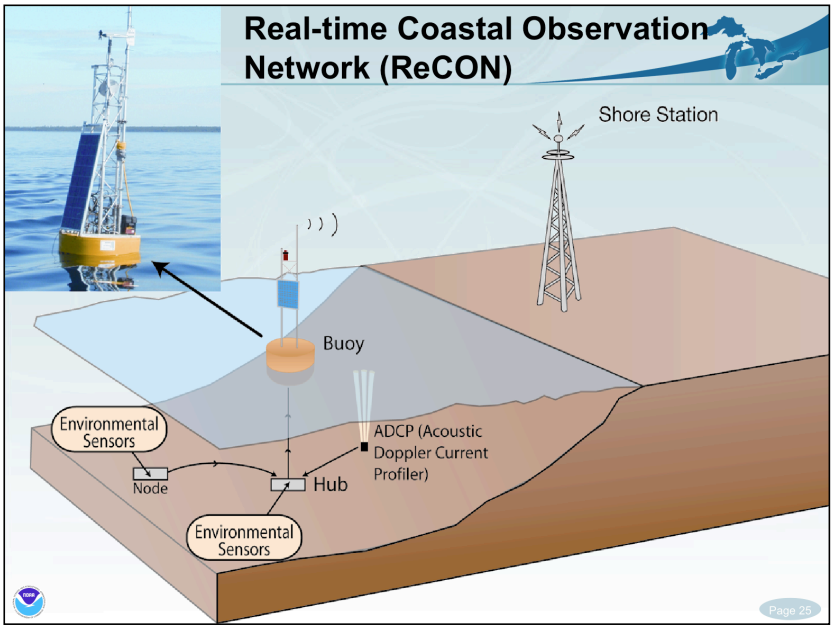
Genetics

Marine Instrumentation Lab (MIL)



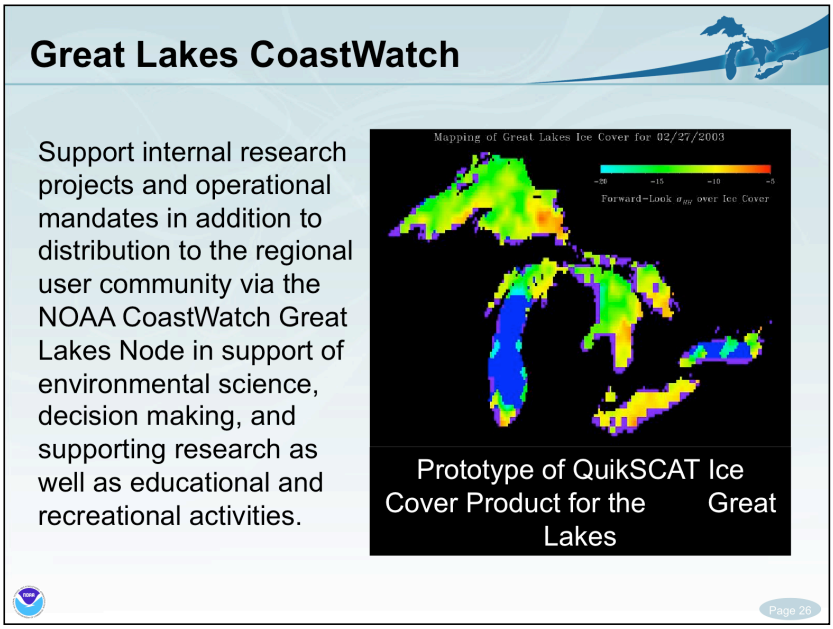
Micro-cinemotography

Reviewers have been provided with an overview and tour of some of GLERL's laboratory capabilities.

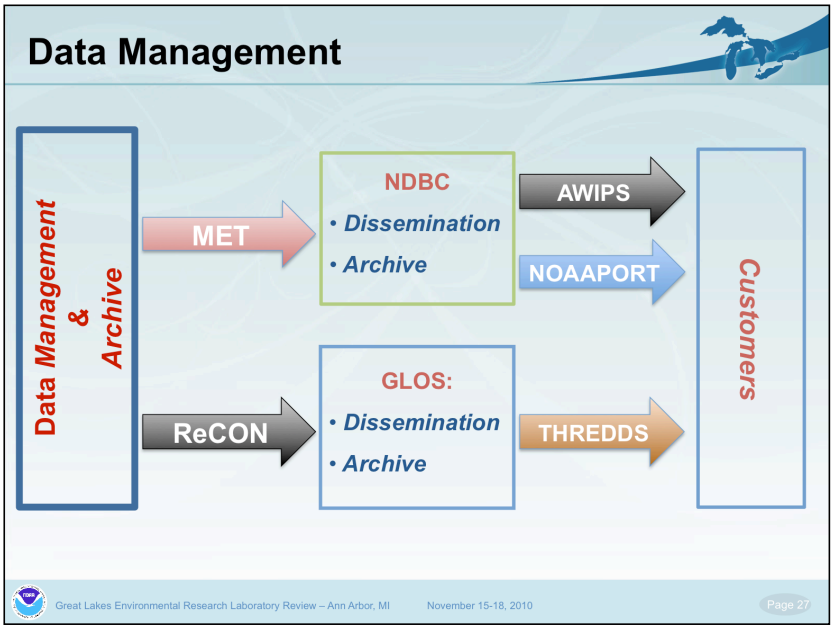


We've discussed the Observation Network relevant to modeling and forecasting and societal needs.
Chris Barnes, University of Victoria PI for NEPTUNE Canada
IEEE/MTS Oceans Conference, "Transformational Science"

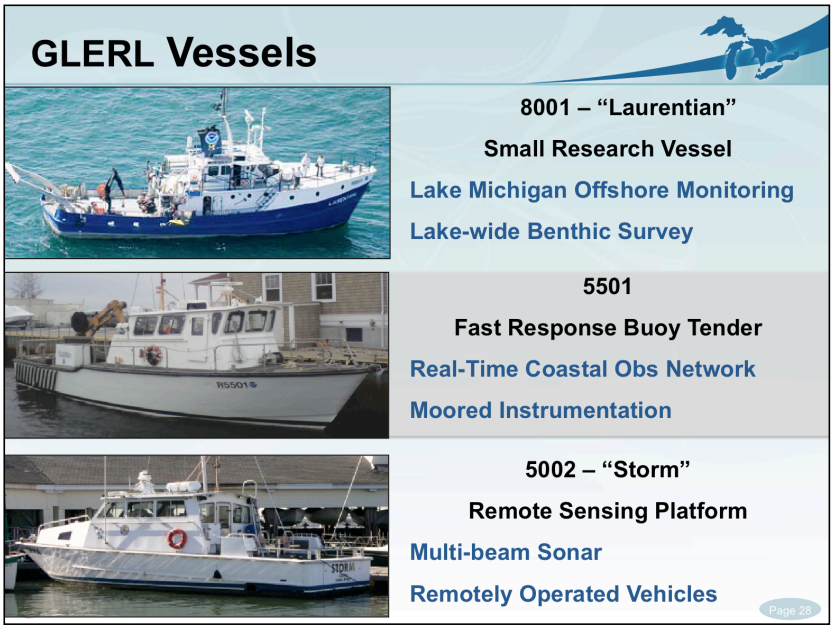
- Using the power and opportunity of the Internet and real-time high bandwidth communications
- Establishing large interactive databases and time-series
- Promoting large community (team) experiments on complex interdisciplinary problems
- Greater inclusion in education and public outreach
- Liberating knowledge to the general public



We've discussed satellite research and products.



We've discussed Data Management at GLERL.



And we've discussed the NOAA Great Lakes fleet and plans for observations.

Conclusions

GLERL's analytical laboratories provide a process-level understanding of ecosystems and support calibration/validation/verification

Observing Systems and Advanced Technology theme both supports and leads science directions

GLERL is working towards an operational, multi-stage Great Lakes observing system to enable transformational science

Questions?